Historical Roots of Algorithmic Art

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Abstract:
Algorithmic art, otherwise known as generative art, is gaining popularity as a new medium for aesthetic creation using computer-generated automation. It is also seen as a potentially powerful platform toward enhancing the understanding of AI. The use of AI to create art has not evolved without causing some controversy: firstly, algorithmic art has a reputation for being controversial in terms of the value of the artwork it produces; and secondly, algorithmic art is seen as fake by many artists as the creative process is being undertaken by a computer. In this paper I will show how algorithmic art has been around for much longer than most people know. Starting with early Islamic art and ending with the contemporary art world, I will show how it has led creativity throughout several genres and what the future holds.

Introduction:

However, it's not that algorithmic art diminishes creativity in contemporary art, but rather exists as an evolution of influences that have been apparent throughout the history of creativity and the history of art in particular. By exploring the work of some notable mathematical artists and important periods of aesthetic creation across the world and throughout history, this paper recognizes the significant connection algorithmic art has with the traditional mathematical structure of some forms of contemporary art.

Islamic Art:

Algorithmic art has a significant background of influences that is often ignored but that is evidencable as being established on the connection between mathematical structures and contemporary art. Artificial intelligence is extraordinary good at calculation and following instructions. This is why its aesthetic structures appear to replicate one of the most historical and methodical art forms to date: Islamic art. This unique artistry incorporates geometrical patterns and precise calculations to create correlating infinity-like artworks. It was during the golden age of Islamic discoveries when discoveries in math and science became public knowledge. These discoveries leaked onto Islamic architecture and were utilized in creating mind-bending patterns (see fig. 1).

Figure 1. Islamic, or arabqueseque, art and decoration is characterized by intertwining plants and abstract curvilinear motifs.

The geometrical and organic style of Islamic art was known as arabesque. This form of art was considered to represent the transcendent, invisible and perfect God. Some historians believe that mistakes in the repetition of patterns in some Islamic art were intended to represent the imperfect and incomparable nature of humanity compared to God. However, computers are great at designing structures with a perfect and clear form. In other words, a 21st century computer could be perceived as the equivalent of the Muslims' God: invisible, transcendent, and perfect.

Islamic art became a fundamental symmetrical form of art that influenced the way beauty was perceived. Many contemporary artists have been influenced by it, even going as far as replicating it in some of the most famous artworks to date.

As Islamic art influenced and structured the mathematical context of some forms of contemporary art, it also shares the precision and flawlessness of generative art.

Eastern Influence:

Meanwhile, Eastern art was independently influencing art with certain components of math. More specifically, Japan is an accurate example where geometry really resonates in their drawing technique and style. Additionally, Japan is home to one of the most unique art forms that rely on specific techniques and pinpoint accuracy to achieve the greatest most beauty possible: origami. Origami is known for containing extremely detailed instructions and complex processes. This is because, unlike other forms of art, the artist must follow a certain procedure for making a shape or object in origami. It is not an activity where the artistic aspect relies on separate materials for straightforward creation, but it is an activity that requires a lot of planning and experimentation with a single product. This can be directly correlated with algorithmic art, primarily because both forms of art utilize specific procedures. For example, algorithmic art has a coding platform so the computer can read instructions to make a product. Computers do not have spontaneous knowledge to improvise in an unfamiliar context; much like the way a beginner at learning origami is clueless until a mentor provides detailed steps. Additionally, in Japanese art culture, the complex architecture of the temples has some correlation with math and ultimately modern-day algorithmic art.

Much like Islamic religions and temples, Japan has its own way of representing its religious beliefs. Japanese shrines consist of a very unique

Figure 2. A temple in Kyoto, Japan, built geometrical principles recorded on Sangaku tablets.

mathematical structure. The most famous and renowned temples are found in the city of Kyoto (see figure 2).

Japan is known for adopting the very unorthodox geometrical style found there into its historic traditions. Temple Geometry started receiving popularity during the Edo Period. During this period, Japan was led by a strict military dictatorship called the Tokugawa Shogunate. This dictatorship led Japan into a very long period of isolation.

Japan used a very unique method of building new temples that provided checkpoints for its cultural development. This mathematical method was recorded on what are known as Sangaku tablets. The tablets consisted of specific formulas and instructions for the Japanese people to reference when building their temples. The contents of the Sangaku tablets are unknown to historians because of Japan's tightly restricted history. Their secrecy is what makes these temples so unique.

We can easily connect this to algorithmic art because, similar to how how Japan used a medium to write mathematical instructions to directly build precise dimensions of temples, algorithmic art also uses a similar medium. A computer program acts metaphorically as the Sangaku tablet —while the code within the program acts in a similar way as the scriptures written on the tablet.

Western Influence:

Although the Eastern hemisphere has a lot of unique geometrical and pattern-related art, the Western hemisphere had the same impactful inspirations that created artistic cultures of their own. Western art has a very culturally diverse collection of artists and artworks that reflect the many chronological stages in development that have had an impact on society. One of the most prominent stages in the development in art and culture to utilize math was the renaissance period.

The renaissance period was very expansive: development thrived on discoveries in music, art, literature, and science. During this period, many artists used these discoveries to inspire their artworks. The most renowned and famous artist to exploit this tactic is Leonardo Da Vinci. His world-famous artwork, the *Vitruvian Man* (see figure 3), is undoubtedly a piece of art that employed relevant mathematical patterns and coordinated scaling to create an organized and creative masterpiece. Art is always perceived as an abstract way of channeling creativity, but, in reality, it can be a very flexible platform for polymaths such as Leonardo Da Vinci to share his perspective on the personal experiences and philosophical factors of reality.

Another artist that greatly incorporated math in his art to increase the aesthetic pleasures of his artwork is Michelangelo. This expressive genius is known to have created many sculptures, paintings, and structures that combine his imaginative style and precise calculations. Although Michelangelo seems to be an artist that disregards precision and relies on spontaneous creations, he uses a consistent pattern throughout his projects. This pattern is

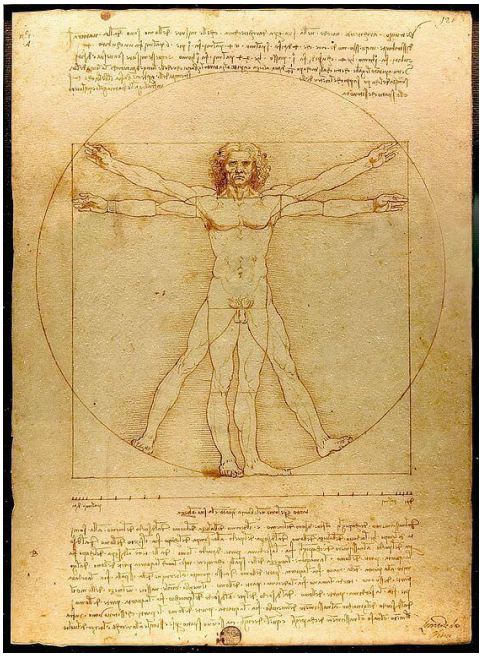

Figure 3. Vitruvian Man by Leonardo da Vinci (c. 1490).

called the Golden Ratio; in mathematics, two quantities are in the golden ratio if their ratio is the same as the ratio of their sum to the larger of the two quantities. When estimated, the golden ratio is approximately 1.6 and is found in artworks such as *The Creation of Adam*. The golden ratio is uniquely found in many natural objects such as snail shells and flower petals, something that has always puzzled scientists. Bizarrely, this rule is frequently utilized by many famous architects, artists, and in the composition of music.

By looking at one of the most influential art movements, we can conclude that math was significantly exploited in highly influential Western art such as that developed during the Renaissance. Algorithmic art follows the same principles these renowned artsists used af it to match it with the modern digital era that we live in today.

Contemporary Influences:

Math and art have a surprising relationship in not only traditional and major art movements, but they also have a unique relationship when it comes to op art. Op art is movement that consists of mind-bending illusions intended to deceive our brains into seeing something different than what is actually present in reality, either on the canvas or visual space created by the op artist. This genre of art is consistently associated with math because of the requirement of precise calculations and specifically oriented patterns to create its effect.

One of the most inspirational artists to create op art is Bridget Riley; she has made countless original pieces of op art that introduced a whole new way of interpreting art using unorthodox mathematics. One of her many artworks that sufficiently represent mathematics integrated in art are her series known as *The Stripe Paintings* made during a long period from 1961 to 2014. Within these striped optical illusions, Riley replicates and balances mathematical method with randomness. She uses two forms that greatly determine the effectiveness of her artwork: global and local entropy. She is known to have integrated these unique systems of description within her overall methodical way of producing art. This greatly connects with the idea of algorithmic art as it too is very methodical and specific when producing the lines of code. However, when this methodical code runs on the generative platform, it is known to create randomly generated and unique

way that optical illusions deceive our mind to produce something beautiful and appealing.

Much like Bridget Riley, there are many various artists that lead the influential movement of the integration of math in artistic forms. These contemporary artists are known to be the earliest dictators of algorithmic art, they include Sol Lewitt, Frank Stella, Maurits Cornelis Escher, and Grace Degennaro. These contemporary artists are known to be some of the most renowned and respected mathematical artists of the 20th century, when abstract art was really starting to take over the perception of how art was represented.

To begin with, let's start off with Sol Lewitt, whose style and artworks incorporate many aspects of daily skills. Unlike many artists of his time, Lewitt is known for breaking the barrier of being one dimensional with his artwork; he also greatly utilizes his environment to compose his art. For example, his wall drawings and incomplete open cube pieces are just a few examples of how he is not scared to use any medium for his creations. Additionally, there is a surprisingly large amount of math involved with his personal style; when observing Sol Lewitt's artwork, it cannot be helped but realize the extreme parallelism within his work. This mathematical device significantly aids the organizational aspect of his artwork. The way he arranges certain lines and shapes creates an illusion of beauty within our minds. This perception of art is something no-one else of his period and managed to create, which made it easily recognizable for the general public.

Moving on, Frank Stella is another revolutionary mathematical artist that pioneered the earliest ideologies of algorithmic art. He was characteristically against the concept of abstract

Figure 4. Parallelism in mathematical art by Sol Lewitt.

expressionism, he believed that art is not derived from a physical or emotional standpoint but just a plain object. Additionally, he invented the genre of maximalist and minimalist art. As controversial as he was, he consistently used unique mediums and tools to initiate his artwork. Frank Stella enjoyed using lithography fluids, and screen printing to create the exact depiction of his artworks. This explains the very solid and exact colors that are shown in his pieces. Additionally, when observing his artwork, one cannot helped but see the strong and solid lines he uses as the basis for creation; hence, where vibrant colors and differentiated patterns are utilized. More specifically, Stella utilized protractors and measurement tools to create his seemingly perfect artwork. Primarily, screen printing helped with the accuracy of the lines and the geometry he incorporated into his work. When screen printing, Stella used an idiosyncratic method where he printed with lithography fluid being guided by a ruler or straight object to direct the liquid. Stella is also

known for using grid lines and accurate graph measurements to control the precision of his artworks.

These examples demonstrate the connection of contemporary art to the concept of algorithmic art: when creating geometrical illusions within the code, it is required to use specific coordinates and locations on the canvas to connect shapes and draw lines. Additionally, Sol Lewitt's parallelism is not only apparent in contemporary art. Within the digital genre, a code called "reflect" in p5.js is an authentic code that mirrors certain objects and geometrical shapes. Therefore, algorithmic art compliments Frank Stella's artwork and Sol Lewitt's unorthodox parallelism.

Even while keeping these historical factors contributing to the creation of algorithmic art in mind, understanding algorithmic art itself is vital in order to ascertain the relationship between mathematics and art.

Beginning of Computer-Generated Art:

Computer generated art started during the 1960's when the first significant step towards the development of computers arose. Simple geometrical shapes were created with the use of heavy and inconvenient machines. Shading was almost impossible on computers during this time because it would have had to be done with practically a pen and paper arrangement with shading strictly limited to basic cross-hatching. Pen plotter drawings tended to be linear which made the act of adding specific content on certain drawings difficult. Frieder Nake, a prominent figure in the development of modern computers, utilized the plotter to add color to certain drawings. Sol Lewitt, mentioned above, used this computer coding art to create a subcategory known as conceptual art. This attracted many other artists to learn programming and how to use computer programs to generate art.

During the early 1970s a revolutionary computer program named AARON was invented by British artist Harold Cohen. This program was unique in the way that it could predetermine the specific body parts that belong to the various torsos of living organisms. This included humans, animals, insects, and more conceptual ideologies like aliens. It proved to be a fully functional computer program that replicated real world objects. This inspired countless upcoming artists to learn programming and utilize AARON for their modernist artworks. Algorithmic art started to evolve seamlessly with the technology that was constantly being updated using the latest software.

Although most coding languages were not being utilized for artistic representations but more for direct instructions for a variety of functionalities, computers were still in the stage of development where specific endeavors were moving forward. The 1980s to 1990s were the most significant stages of computer art development. As computers were discovered to have diverse functionalities, private businesses such as Adobe (launched in 1982), which developed a new form of imagery called Vector, and Microsoft utilized specific aspects to make art within a different

platform. The age of digital automatization held an advantage when conveniently portraying the creation of art. As digital art was becoming more widespread and sparked realization in individual artists about the convenience of this format, people started to appreciate and acknowledge the integration of digital art software into the contemporary scene. However, as the 21st century approached, the works of Manfred Mohr and the specific algorithms he utilized were being recognized, coding programs typically used for Website building and systematic online procedures such as Javascript were integrated into translating contemporary art to surreal digital depictions.

Although digital generative art can be interpreted in a straightforward manner, translations of naturalistic elements within our society through algorithms is something that speaks truths to us and makes ask question things. Not only is generative art reflecting specific naturistic elements of society and our environment, but it also is a method of understanding how AI units function, how they process visual perceptions of our world. Nanjing University researcher CJ Chen states: "Understanding these technologies is important because it impacts the future of all humans, no matter where you are."

Generative art is often seen as a straightforward program that consists of various processes and revisions. However, the truth is contrary to these typical stereotypes that categorize algorithms being part of programming and far from integral as an artistic genre. In his 2010 presentation at the Flash on the Beach conference, Jared Tarbell describes the ideology of generative art as a process of spontaneous "looping." This unique process can create majestic and exotic artworks known to reflect the reality of nature in an abstract way. His art piece *Substrate* is a good example of this process that is not based on complicated foundational code and does mirror familiar characteristics.

Generative art programs not only possess the ability to create visual productions from scratch, but they can also reformat already created images or photographs to a rearrangement of colors and distorted features. Moreover, generative art goes further toward a functionality of replicating the human mind and perceiving certain elements the same way humans do.

Contemporary Algorithmic Art:

A great representation of this new technology is a program called GAN, or Generative Adversarial Networks, created by Ian Goodfellow and his team in 2014. This is the network where most generative artworks involving AI are made. GAN consists of two neural networks intended to replicate the thought process and perception of a human brain. One of the neural networks is a generator while the other is known as a discriminator. One factor that contributes to the similarity between this AI program and our brains is how the "generator" learns and connects similar traits between certain images we input into the network. Therefore, it starts creating a global distorted image based on the training set that

works together with the discriminator to attempt to create the most accurate depiction.

Algorithms produced in generative art with the support of AI usually come through this network to create unique imagery considered art. Similarly, not only are open networks and software produced to accurately simulate a human mind, but many artists and roboticists are also discovering relationships and artistic endeavors regarding the subtle connection between AI and humans. For example, Alexander Reben, an optimistic artist who encourages synthetic psychology, artificial philosophy, and robot ethics, is, in his own words, on a mission to "probe the inherently human nature of the artificial."

Reben has conducted multiple experiments relative to the intimacy and versatility of machines. For instance, a unique experiment that contested Isaac Asimov's first law of robotics. The machine can sense an object—in this context a human finger—and choose whether to pierce it, or not, with a needle. This breaks the first law of robotics which is: "A robot may not injure a human being or, through inaction, allow a human being to come to harm."

Conclusion:

Undoubtedly, the full potential of AI and the similarities between us and automated machines have yet to be discovered. However, generative art has proven that the process of creating art and perceiving reality with machines is extraordinarily parallel to the creation of particular and historical forms of contemporary art and the perception of humans. Society has designed algorithmic art influenced by previous art movements such as Islamic patterns, Japanese architecture, and mathematical artists that defied the laws of creativity. Generally, we expect generative art to feel artificial and monotone; however, from observations and experimentations in the overall nature of AI and art pieces utilizing automated software, it is conclusive that whether we believe it or not, AI is approaching the point of being able to replicate the human mind and contemporary art is just at beginning to discover its full potential in terms of artistic production.

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